

Summary and Conclusion

World Health Organization (WHO) states that obesity is one of the most common, yet the most neglected public health problems in both developed and developing countries (WHO,2000). The phase I study of ICMR-INDIAB (2015) revealed that the prevalence of generalized obesity was found to be 24.6 per cent among the residents of Tamil Nadu. Asian Indians have a greater predisposition to abdominal obesity and accumulation of visceral fat and this has been termed as “Asian Indian phenotype”. In countries like India, the rise in obesity prevalence could be attributed to the increasing urbanization, use of mechanized transport, increasing availability of processed and fast foods, increased television viewing, adoption of less physically active lifestyles and consumption of more “energy-dense, nutrient-poor” diets.

The sudden marked increase in obesity has been ascribed to changes in lifestyle factors, since this escalating prevalence has been occurring in a constant genetic milieu. Genetic strategy is considered as an important clue for envisaging the pathological mechanism behind the development and progression of metabolic syndrome. However, the genetic pathways leading to obesity remain elusive although the great success in genetic researches. It is of great significance for prevention and treatment of obesity by searching for candidate genes.

One commonly studied candidate gene for obesity is peroxisome proliferator-activated receptor gamma (PPAR- γ) gene. Peroxisome Proliferator-activated receptor γ is a key regulator of adipogenesis, responsible for fatty acid storage and maintaining energy balance in the human body. Studies on the functional importance of the Peroxisome Proliferator Activated Receptor (PPAR Gamma), Pro12 Ala polymorphic variants indicated that the observed alleles may influence body mass measurements. Pro 12 Ala polymorphism was associated

with increased BMI and the possible role of ala 12 isoform in contributing to the susceptibility for metabolic disorders in obesity. However the genetic influence with regard to specific polymorphism in south Asian population is not yet clearly exhibited with reference to dietary, physical activity and nutrition education intervention. This kind of study can lead to personalised nutrition based on SNP. Hence, this study was aimed to determine the prevalence of obesity among young adult of the age group 19-24 years and to find out the influence of pro12ala of PPAR Gamma 2 on outcome of interventions.

The present study entitled **“Evaluation of a Functional Food Supplement on Body Composition of Obese Young Adults and Influence of a selected PPAR Gamma Gene Polymorphism on its Outcome”** was carried out with the specific objectives to establish association between aetiology, body composition measures and anthropometry among young adults, conduct gene analysis and find the association of PPAR Gamma polymorphism in obesity, evaluate the impact of interventions on body composition, anthropometry and PPAR Gamma polymorphism to explore the relation between body composition, lipid profile, physical activity and genetic polymorphism. A total of 1873 subjects comprising of 990 male and 883 female individuals were enrolled for the purpose of screening obese and overweight subjects among young adults in the age group of 19-24 years.

In the phase I, a total of 1873 subjects in the age group of 19-24 years were chosen and screened for obesity and overweight. The gender and age wise distribution of the subjects based on the anthropometric measurements such as height, weight, Body Mass Index, Waist hip ratio, waist to height ratio, Conicity index, body adiposity index were assessed for all the subjects. The prevalence of obesity and overweight among young adults were also studied. Based on BMI, the subjects were categorised as underweight, normal, overweight and obese.

Phase II of the study consisted of formulating, standardising and evaluating the functional food mix and their health benefits. The functional food

supplement was prepared by incorporating functional foods and it was analysed for nutrient content, nutraceutical potentials and shelf life study was conducted.

Socioeconomic status, body composition measurements, energy expenditure, prevalence of metabolic syndrome, base line biochemical profile, food and nutrient intake, resting and total energy expenditure by using common prediction equation were assessed at baseline which formed the Phase III of the research.

In phase IV, the interventions were carried out for the selected sub sample of 130 subjects. Equal number of males (N=75) and females (N=75) were recruited and in each category all the three phenotypes such as obese (N=25), overweight (N=25) and normal (N=25) were included. The intervention included dietary, physical activity and nutrition education for all the obese and over weight subjects. Normal subjects served as the control. As a part of dietary intervention, 50g of the prepared supplement was given to the subjects daily for a period of 4 months. In physical activity intervention, a set of twelve exercises were instructed to be performed by the subjects for 45 minutes each day. The physical activity intervention was given on alternate days. Nutrition education was given to all the subjects.

In Phase V, the pro 12 ala polymorphism of PPAR Gamma gene polymorphism analysis was carried out. The subjects were categorised based on genotype and phenotype. The genotypes were further categorised as subjects with polymorphism (pro 12 Pro) and subjects without polymorphism (pro 12 pro). The impact of intervention with reference to genotype (pro 12 ala and Pro 12 pro) as well as phenotype (obese, overweight and normal) were analysed for both males and females separately and discussed. The impact of intervention with regard to mean changes in anthropometric measurements, biochemical parameters, body composition measures, energy intake, energy expenditure and energy balance. The salient findings of the study are presented below.

Phase I

- Body Mass Index of 18.50 to 22.9 were categorized as normal, 23.0 – 24.9 as overweight and ≥ 25 as obesity according to the revised guidelines in the place of the ethnic specific BMI previously advocated for Asian Indians
- The distribution of subjects based on Body Mass Index and gender revealed that prevalence of obesity was 19.91 and 23.21 per cent among the male and female subjects respectively. Prevalence of overweight among the selected subjects were found to be higher among females (22.87%) than males (13.33%). 62.12 per cent of the male subjects had a normal Body Mass Index while only 37.37 percent of the females had a normal Body Mass Index. The prevalence of underweight was higher among the female (16.53%) than among male subjects (5.35%).
- The mean weights of the selected male subjects (60.50 ± 8.38) were found to be more than the female subjects (56.44 ± 12.28). The mean weights of both the groups were found to be less than the reference standard weight for their respective gender. The mean Body Mass Index of the selected male (22.26 ± 2.93) and female (22.47 ± 3.91) subjects were found to be similar.
- Stratification of mean height based on body mass index and age revealed that the mean height of the males were 174.88 ± 4.94 in the 23 years age group and the females were 157.59 ± 5.74 in the 20 years age group which was found to be the highest among underweight subjects
- The age wise distribution of the subjects based on weight and phenotype revealed that the male subjects of all the age groups weighed more than the females excepting the obese female group invariable of the phenotype and age, the mean weight of the male and female subjects were found to be highest among the obese group.
- In the obese category, the male subjects recorded a maximum (0.60 ± 0.04) mean Waist to Height Ratio in the 23 years age group and a

minimum (0.50 ± 0.04) in the 22 years age group. The female subjects recorded a maximum (0.56 ± 0.07) mean Waist to Height Ratio in the 24 years age group and a minimum (0.51 ± 0.06) in the 19 years age group.

- The mean Conicity Index observed in the obese male subjects were higher (0.90 ± 0.10) in those who were 23 and 24 years of age and lower (0.80 ± 0.10) in those who were 20 and 22 years of age. The mean Body Adiposity Index studied among the underweight male subjects was found to be maximum (22.51 ± 2.62) in those who were 22 years old and minimum (21.03 ± 1.65) in those who were 23 years old. With Weight, a strong positive correlation ($p < 0.01$) was seen among BMI, waist height ratio, waist circumference, hip circumference, waist hip ratio, body adiposity index and dietary pattern of the subjects. BMI showed a strong positive correlation ($p < 0.01$) with waist height ratio, waist circumference, hip circumference, waist hip ratio, conicity index, body adiposity index and dietary pattern of the subjects.

Phase II

The results of the standardization, development and evaluation of the functional food supplement revealed the following:

- Among the three variations, variation I gained significantly high score ($p < 0.01$) than the variation II and III prepared using functional food supplements.
- The developed functional food mix was found to be rich in macro and micronutrients. The energy content was found to be 336.37 Kcal. While, its protein content was found to be 17.47g and fat content was found to be 6.81g.
- The results of phytochemical screening showed the presence of maximum secondary metabolites (alkaloids, tannin and phenolic compounds, flavonoids and protein) in all the ingredients of the food supplement in ethanol extract than aqueous extract. The supplement exhibited

151.96±1.98 mg/100g of gallic acid equivalent of flavonoids followed by the aqueous extract of the supplement containing 12.238±0.33 mg/100g. Non enzymatic antioxidant like total reduced glutathione (70.34±0.21) were found to be in high concentration in the functional food supplement. The maximum DPPH activities in the food supplement of ethanolic extract were due to the high polyphenolic content of the food supplement exhibited in the quantification of phytochemical constituents. The values of the 50 per cent inhibition concentration (IC₅₀) of the food supplement in ethanolic extract were 39.17µg/ml. The ethanolic extract of the food supplement had high ferric reducing antioxidant power than aqueous extract of the food supplement compared with standard ascorbic acid at the concentration of 2.5 mg/ml. It was evident that functional food supplement showed a higher ferric reducing ability. The highest scavenging activity on nitric oxide radical was 58.6% for the extract at a concentration of 500µg/ml when compared to that of vitamin C as a standard (77.4%).

- The functional food supplement exhibited above 70 per cent of pancreatic lipase inhibition at certain concentration which would have a great impact on the health of the individuals.
- The study on shelf life revealed that at the 0th day, the total bacterial count and total fungal count were below the detectable level. The peroxide values were found to be 0.79, 1.03 and 2.05 at 7th, 15th and 30th day respectively. The keeping quality of the functional food mix was found to be best within one week of preparation

Phase III

- The education status of the head of the family revealed that an appreciable percentage of the males (54%) and females (49 %) had qualified under graduation followed by 11 per cent of the males and 8 per cent of the females who had completed post graduation.

- The total family income classification as per 11th Five year plan (2007-2011) was used to stratify the families which revealed that almost 55 of the females and 43 per cent of the males lived in the families who earned between Rs. 7301 to 14500.
- Food habits of the subjects revealed that 63 per cent of the males and 14 per cent of the females were vegetarians whereas 75 per cent of the females and 34 per cent of the males were non-vegetarians. The meal pattern of the individual depends upon the family and the community to which they belong, 88 per cent the male subjects and 77 per cent of the female subjects reported to consume three meals a day while 23 per cent of the females and 9 per cent of the males consumed 2 meals a day.
- Forty three per cent of the males and 11 per cent of females skipped their meals frequently while 89 per cent of the males and 57 per cent of the females consumed their food regularly. Eighty six per cent of the females and 57 percent of the males spent nearly 6-9 hours in the college comprising of academic and co-curricular activities which constituted the major duration of their daily activities. Television viewing by the subjects revealed that majority of the males (81 %) and 18 per cent of the females watched television from 30 minutes to 1hour/day
- Base line anthropometry data revealed that the mean weight of the obese male subjects was recorded as 84.43 ± 11.52 kg whereas in the females, it was found to be 67.49 ± 10.63 kg. Among the overweight males the mean weight was found to be 71.43 ± 6.49 kg and in the female subjects, it was 59.28 ± 4.64 kg. The mean weight of the normal male subjects was 58.57 ± 5.83 kg and the female subjects were 51.35 ± 4.78 kg.
- Analysis of baseline biochemical parameters revealed that all of them were within the normal range among all the subjects. The INBODY 720 body composition analyser, a 4 compartmental model, was used for measuring the body composition. The visceral fat area determined for the

obese male subjects was $108.81 \pm 28.31 \text{ cm}^2$ whereas in the females, it was found to be $86.48 \pm 27.35 \text{ cm}^2$. In the overweight group, the VFA recorded for the males revealed that it was $73.39 \pm 10.17 \text{ cm}^2$ and in the females, it was found to be $67.44 \pm 8.93 \text{ cm}^2$. VFA of the normal male and female subjects was found to be $46.71 \pm 18.84 \text{ cm}^2$ and $48.32 \pm 17.06 \text{ cm}^2$ respectively

- The Basal Metabolic Rate (BMR) assessment through the INBODY 720 body composition analyser showed that among the obese male and female subjects, it was around 1578.04 ± 142.37 and 1181.85 ± 130.37 respectively. Thirty five per cent of obese male subjects and 50 per cent of the obese female subjects presented with metabolic syndrome. Among the overweight male and female subjects, the metabolic syndrome was present in 28 per cent of the males and 41 per cent of the females respectively. Among the normal males, metabolic syndrome was present in 5 per cent and that of the females, it was 17 per cent
- The overall mean REE based on all the equations were also computed and the results revealed that in the obese male and female subjects, they were 1883.67 ± 93.94 and 1417.67 ± 75.01 . The overall mean TEE based on all the equations were also computed and the results revealed that in the obese male and female subjects, they were 2435.3 ± 483.84 and 1873.36 ± 308.84

Phase IV

- The prevalence of Pro 12 Pro was found to be 78.3 and 75 percent among male and female obese subjects. An equal per cent of male and female subjects (77.27%) exhibited pro 12 pro polymorphism among the selected overweight subjects while around 95 and 91 per cent of the normal male and female subjects were identified to possess pro 12 pro polymorphism.
- The differences in weight for the male and female obese subjects after intervention were found to be -4.79 ± 1.28 and -3.52 ± 1.13 which showed

the efficacy of the functional food supplementation and the exercise regimen that were followed by the subjects.

- There was a notable change in the BMI of the male and female obese subjects which were -1.57 ± 0.49 and -1.35 ± 0.52 respectively. A reduction in BMI is a positive outcome of the dietary and activity intervention of the selected subjects. The differences in weight of the male overweight subjects were found to be -4.76 ± 1.58 and that of the females were found to be -4.30 ± 1.00 .
- Subjects with pro 12 ala polymorphism had a higher body weight and BMI at baseline when compared with subjects with pro 12 pro genotype. Among the variants, weight reduction was more pronounced among the males when compared with the females. Differences were also observed in the BMI of the male and female overweight subjects with polymorphism and were found to be -1.57 ± 0.54 for the males and -1.67 ± 0.39 for the females.
- The differences in the body fat mass of the overweight male and female genotypes with polymorphism showed a decline of -5.74 ± 2.94 and -2.28 ± 3.00 respectively while in the genotypes without polymorphism; the differences were -2.15 ± 3.76 and -1.45 ± 1.40 respectively.
- The visceral fat area determined for the male and female obese genotypes with polymorphism, a decline was observed and were found to be -16.60 ± 17.91 and -17.48 ± 16.02 respectively. Among the obese male and female genotypes without polymorphism, the differences were found to be -11.05 ± 8.97 and -11.61 ± 43.03 respectively. The VFA of the male and female phenotypes belonging to the same category showed a reduction which were recorded as -12.26 ± 11.22 in the males and -13.08 ± 37.75 in the females
- The percent body fat analysed for the subjects before and after intervention showed a decline in all the groups, among the male and

female genotypes with polymorphism, the differences observed were -4.46 ± 6.30 and -2.30 ± 2.77 respectively. Whilst in the genotype without polymorphism, the differences recorded were -3.04 ± 5.89 and -3.29 ± 10.88 respectively. The difference observed in the male and female phenotypes were -3.35 ± 5.87 and -3.04 ± 9.43 respectively.

- When the total cholesterol was determined for the obese male and female genotypes with polymorphism, there was an appreciable reduction in the total cholesterol content amounting to -9.20 ± 7.78 and -42.2 ± 12.1 mg/dl respectively. The total cholesterol content also showed a decline in the obese male and female phenotypes which were -12.26 ± 13.34 and -27.3 ± 15.2 mg/dl respectively. The total cholesterol determined for the overweight male and female genotypes with polymorphism showed that there was an appreciable reduction in the total cholesterol content amounting to 9.80 ± 8.26 and 46.8 ± 28.0 mg/dl respectively
- The triglycerides were estimated pre and post intervention and the differences in the obese male and female genotypes were found to be -3.80 ± 44.55 and 34.2 ± 24.0 mg/dl respectively. The mean TC, TGL, LDL were found to be higher among the subjects with pro 12 ala polymorphism and a greater reduction after intervention were also noted in subjects with pro 12 ala polymorphism
- The differences in the energy balance of the obese genotypes with polymorphism showed a difference of -1066 in the males and -1012 in the females and in the genotypes without polymorphism, the differences were -1164 for the males and -973 for the females. Among the male and female phenotypes, the energy balance differences were observed to be -1104 and -994 respectively. The energy balance in all the groups were found to be negative that proves the efficacy of the interventions among the selected subjects in the present study.

- The final energy intake was found to be lower when compared with the initial energy intake and the energy expenditure was found to be higher when compared with the final energy expenditure in almost all the groups.
- The spurt in the prevalence of obesity as a precursor to major health problems globally necessitates appropriate intervention strategies to safeguard the health of the youth. The results obtained from the above findings validate that reduced energy intake and increased energy expenditure were instrumental in creating a negative energy balance that enhanced weight loss.
- Dietary intervention with the functional food components had played a major role in the overall improvement of the anthropometric and biochemical profiles of the obese subjects. The improvements in health and overall wellbeing showed the efficacy of the interventions that were well documented among the subjects.

The present study results proves the efficacy of functional food supplement on reduction in body weight, body fat per cent and visceral fat area. Pro 12 ala polymorphism was high among obese and overweight subjects. Long term intervention would throw more light on the efficacy.

Recommendations

- Long term studies on food supplementation with functional food could be attempted.
- Correlation studies on etiological factors and body fat could be attempted
- Impact of physical activity on anthropometric measurements.
- Correlation studies on gene polymorphism and obesity
- Prevalence studies on large sample size covering the entire state
- Studies on SNP analysis in obese diabetic population

- Novel functional foods for weight reduction
- Inclusion of herbal supplementation for weight reduction
- Other SNP related to obesity could be studied